

Seeing (and Listening to) the Falling Trees: Subaperture Imaging in SAR

Dr. Warren Smith

Dan Filiberti

Dr. Douglas Granrath

Mary Lawler

Steven Pothier

Science Applications International Corp., Tucson, AZ

Presented at the NDIA Night Operations Symposium

March 12, 2002 New Orleans LA

This work has been supported in part by the Defense Advanced Research Projects Agency.

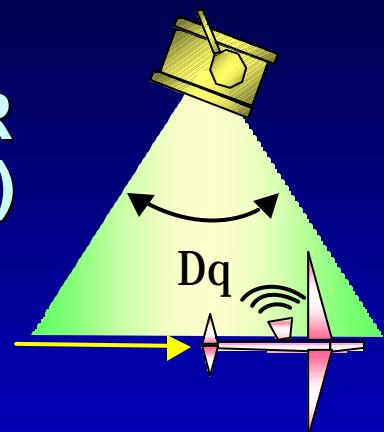
warren.e.smith@saic.com

OUTLINE

- Goals
- Continuous dwell
- Subaperture analysis
- Application to polarimetric data
- Audio encoding
- Summary

Goals and Approach

- **Goals**
 - estimate scatterer changes across the SAR phase history (i.e., along the sensor's path)
 - aspect-dependent scattering
 - target-geometry changes during acquisition
 - apply to multiband; e.g., polarimetric, data
- **Applications**
 - target detection & recognition
 - continuous-dwell imaging of transient events
- **Approach**
 - sub-aperture analysis
 - pixel-stability mapping
 - analysis of multiband decomposition products



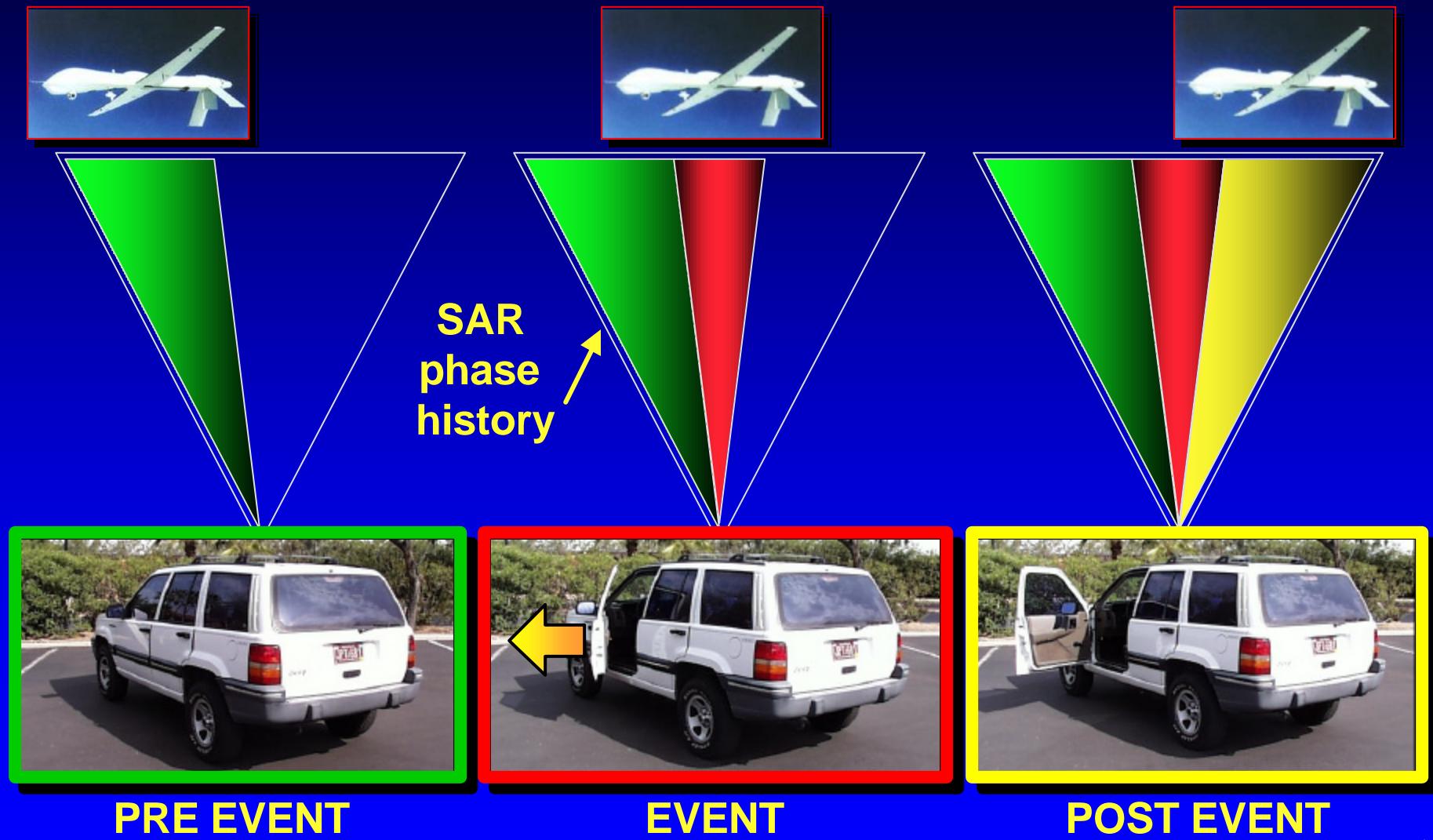
Continuous-dwell Imaging

- **Detection of event**
 - Coarse-to-fine analysis
 - Spatio-temporal event detection
 - Time-frequency analysis after event detection

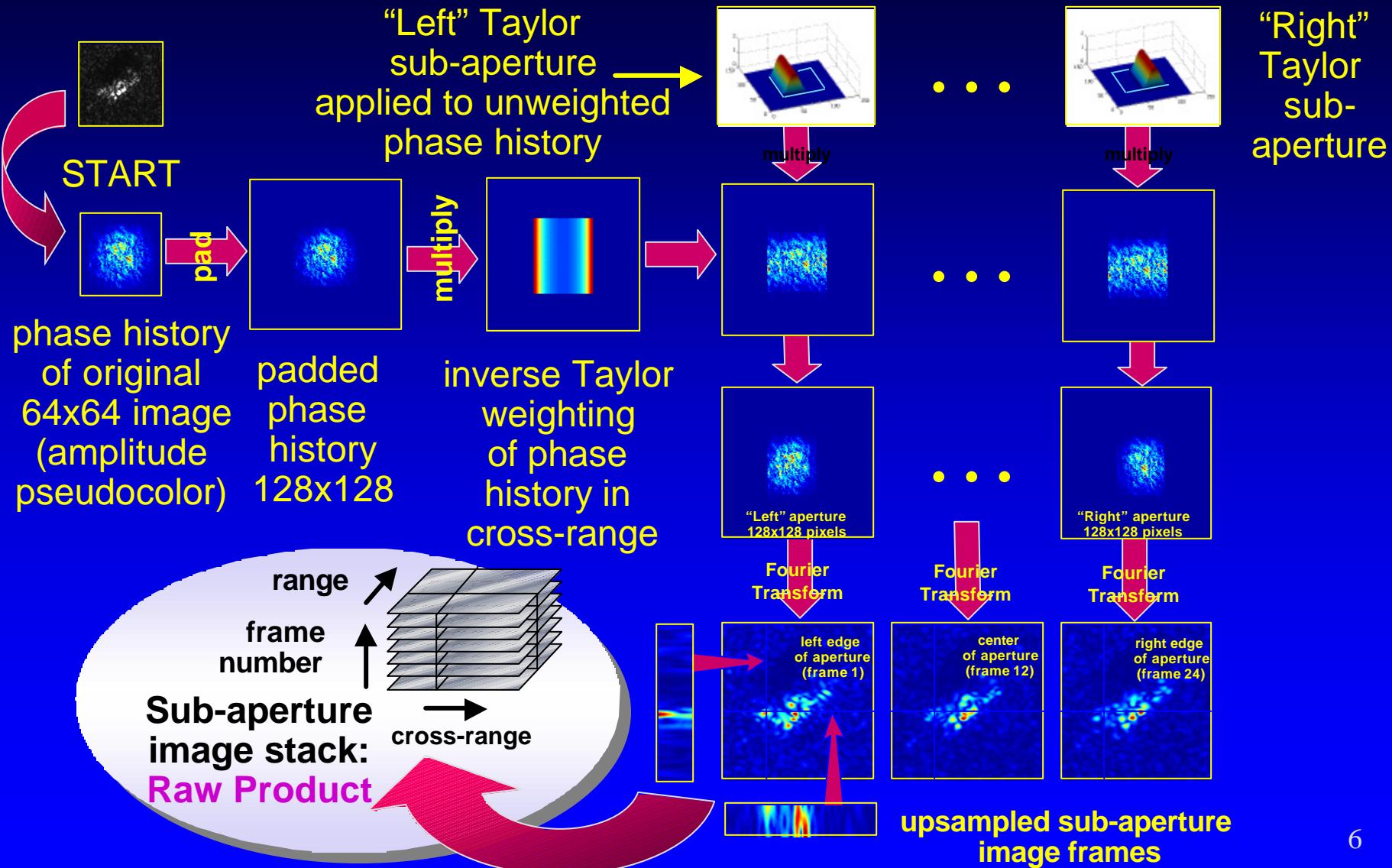
- **Characterization of event**
 - Onset
 - Duration
 - Target motion/vibration
 - Location: on or near target
 - Detection of sub events



Continuous-dwell CONOPS

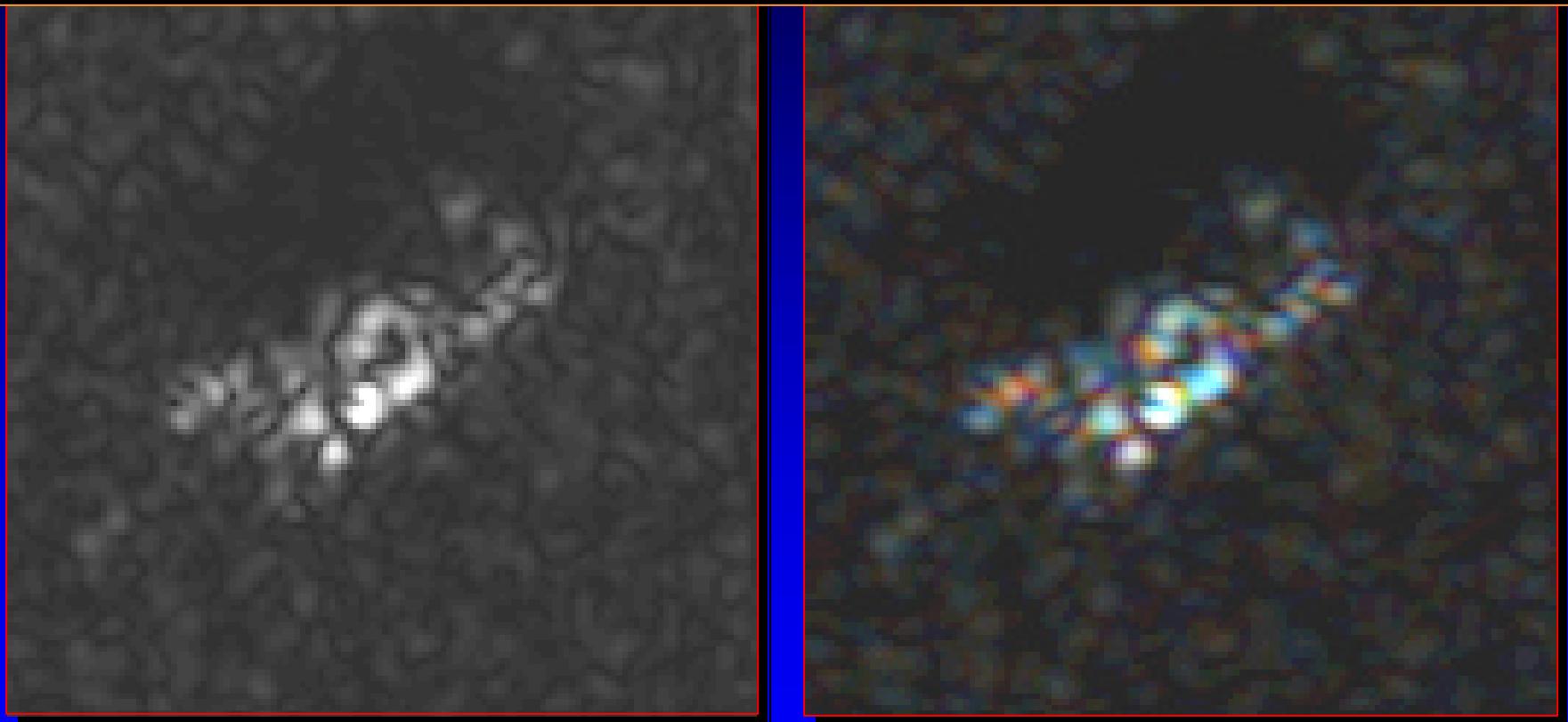


Sub-aperture Analysis



Sub-aperture Analysis: Example

aperture-dependent scatterer properties can be quantified



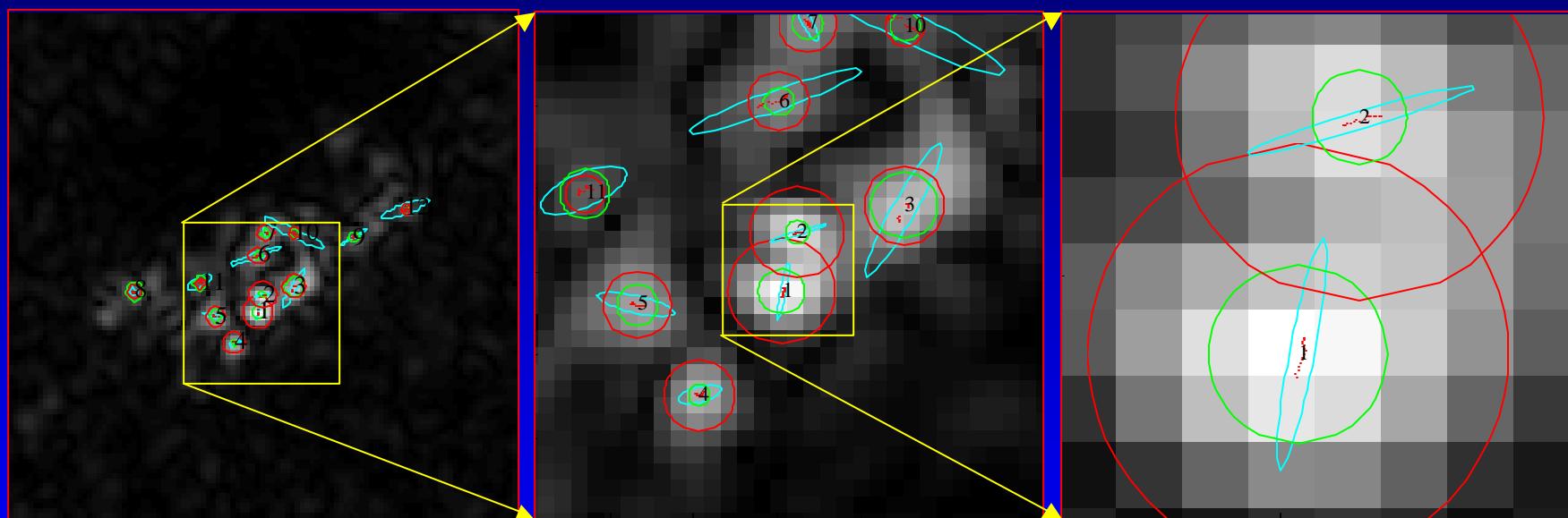
T72 @ 45 deg
magnitude

red = left aperture
green = middle aperture
blue = right aperture

Peak Movement Across Aperture

Peak Movement:

- Trace sub-aperture peak centers through volume
- Estimate peak-location uncertainty from movement of centers



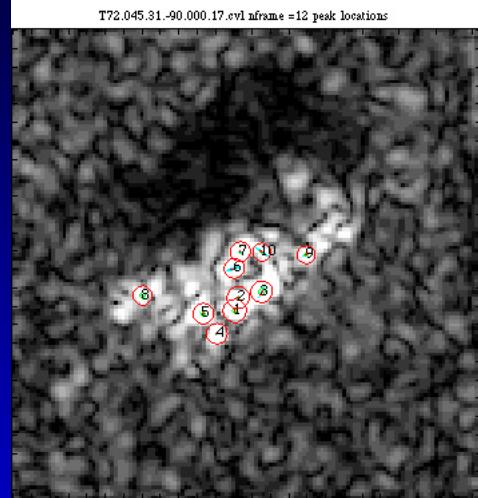
RED = AMPLITUDE

GREEN = STABILITY (smaller is more stable),

CYAN = POSITION UNCERTAINTY

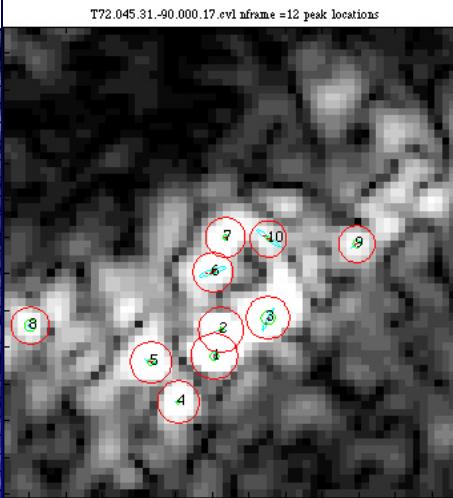
Pixel Stability Maps: T72 Example

T72.045.31.-90.000.17.cvl nframe =12 peak locations



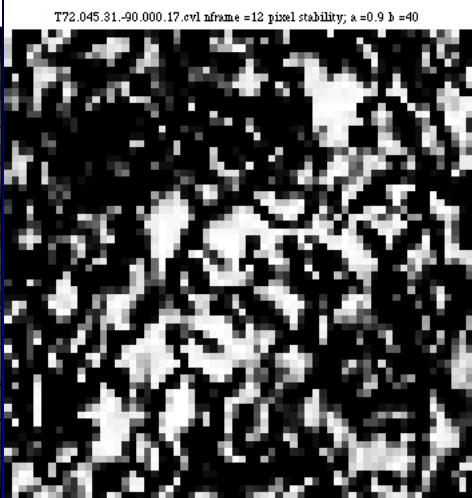
full-aperture, overview

T72.045.31.-90.000.17.cvl nframe =12 peak locations



full-aperture, upsampled

T72.045.31.-90.000.17.cvl nframe =12 pixel stability; a =0.9 b =40



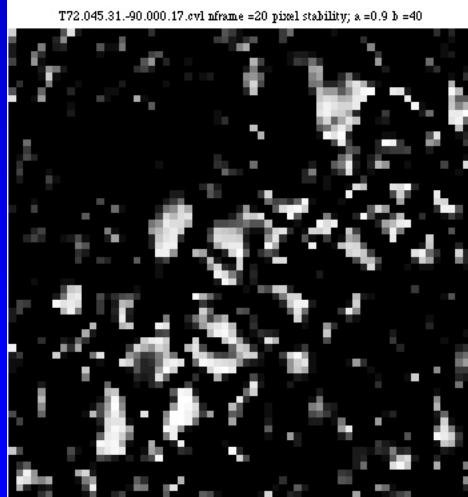
12 frames

T72.045.31.-90.000.17.cvl nframe =16 pixel stability; a =0.9 b =40



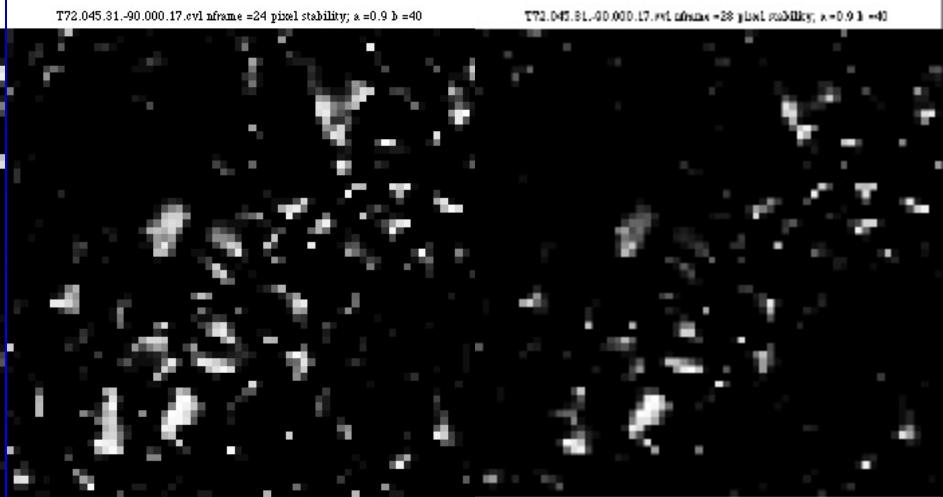
16 frames

T72.045.31.-90.000.17.cvl nframe =20 pixel stability; a =0.9 b =40



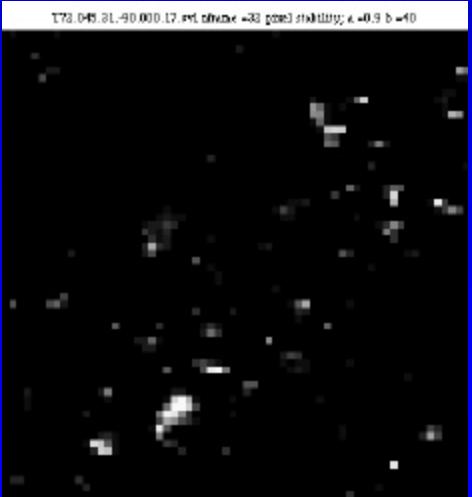
20 frames

T72.045.31.-90.000.17.cvl nframe =24 pixel stability; a =0.9 b =40



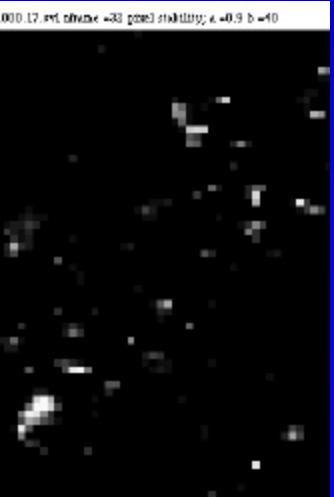
24 frames

T72.045.31.-90.000.17.cvl nframe =28 pixel stability; a =0.9 b =40



28 frames

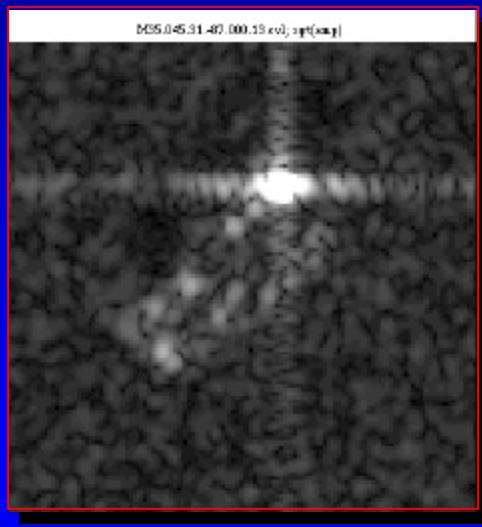
T72.045.31.-90.000.17.cvl nframe =32 pixel stability; a =0.9 b =40



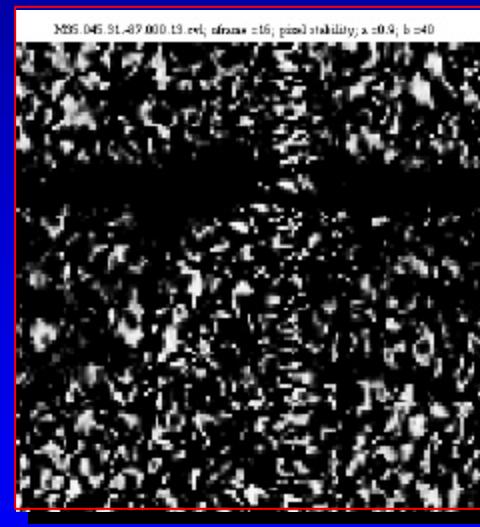
32 frames

Weighting with Stability Maps: M35 Example (measured data)

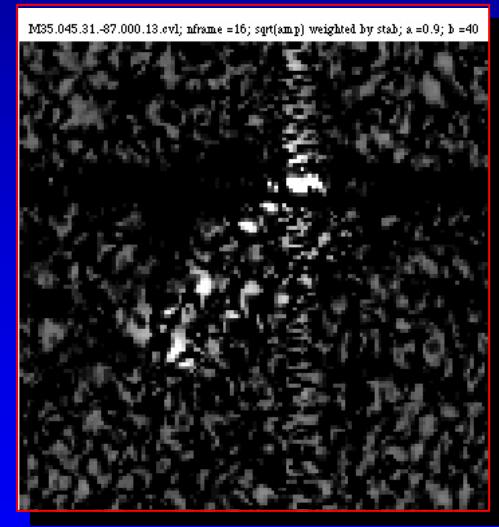
- Cross-range artifacts (e.g., sidelobes) can be suppressed by the stability map
 - e.g., M35 truck bed



X



=



45 deg aspect, sqrt(amp)

16-frame weights

weighted original

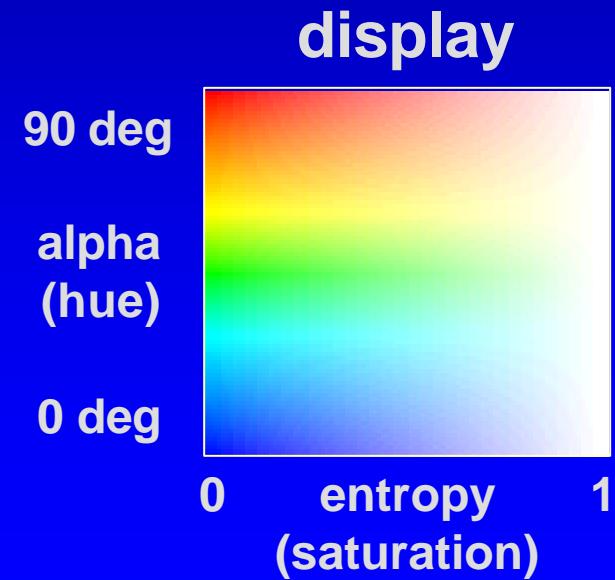
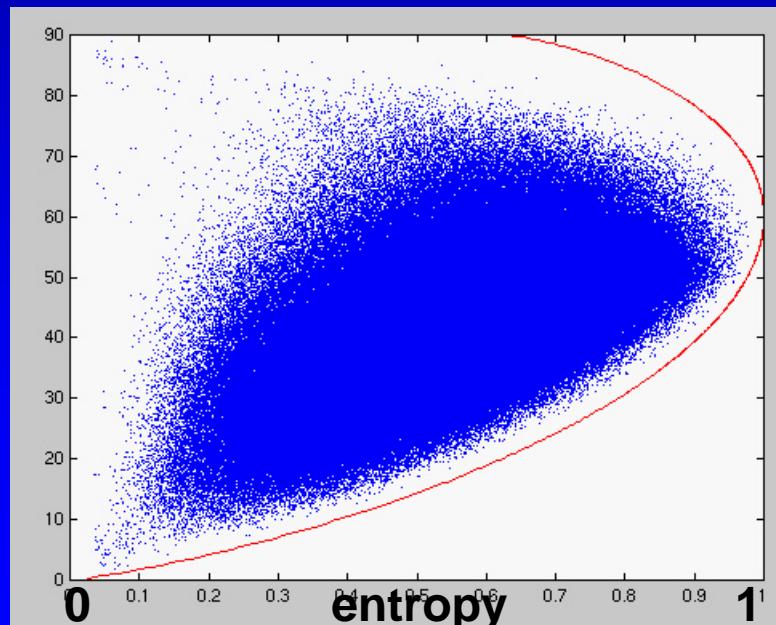
Alpha, Entropy Overview (Cloud)

- **Alpha a, Beta b**
 - a is measure of scatter type, b is related to scatterer orientation
 - Derived from eigenfunctions of neighborhood scattering matrix
- **Entropy H**
 - Measure of polarization purity
 - $H = 0$: pure state; $H = 1$: depolarized

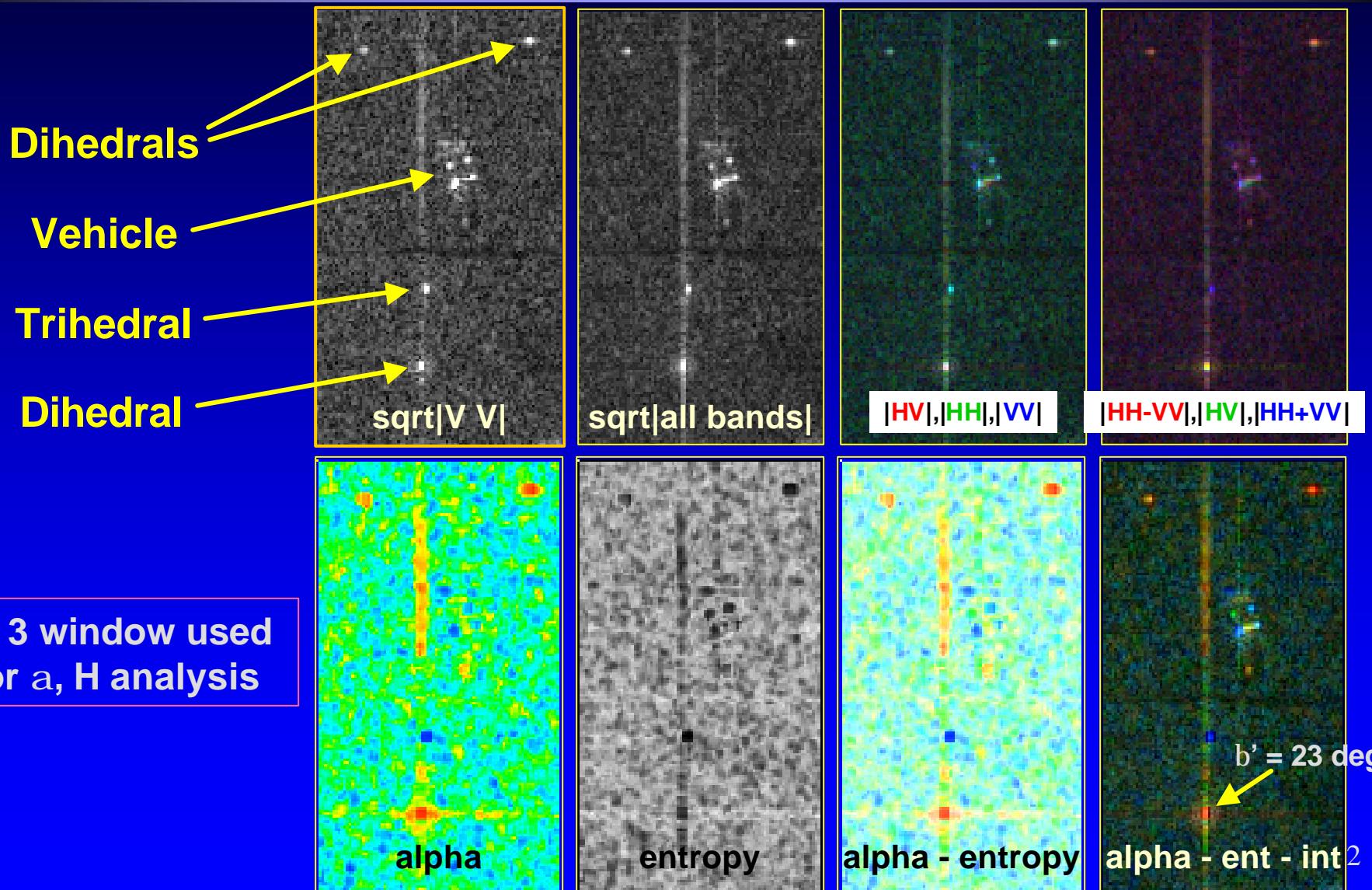
$a = 90 \text{ deg}$
(dihedral)

$a = 45 \text{ deg}$
(dipole)

$a = 0 \text{ deg}$
(surface)

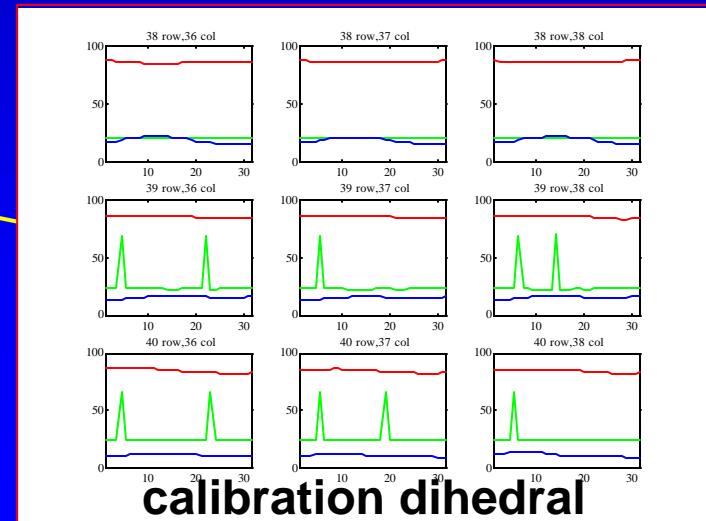
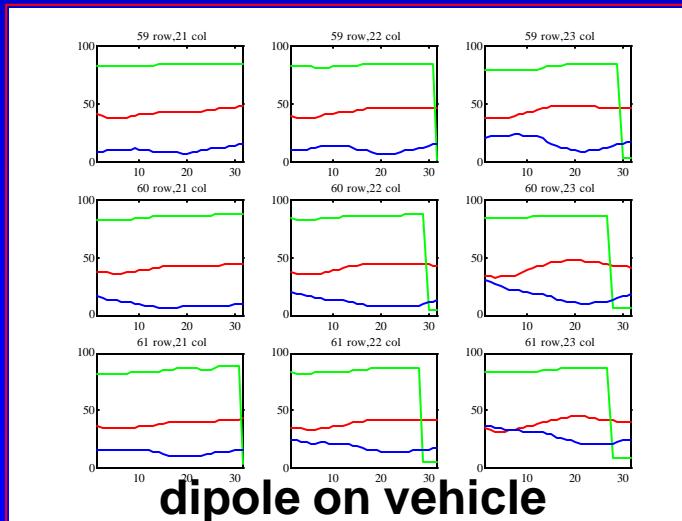
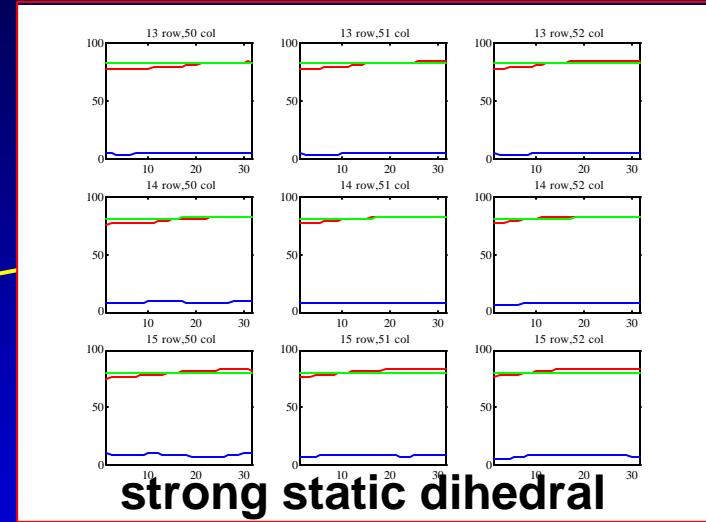
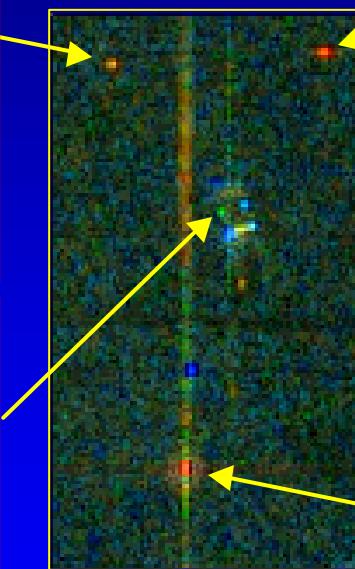
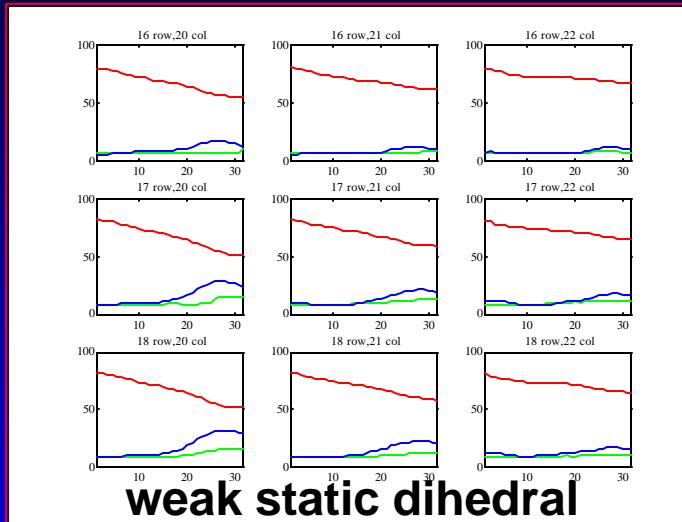


Alpha, Entropy Analysis: ADAS Sensor



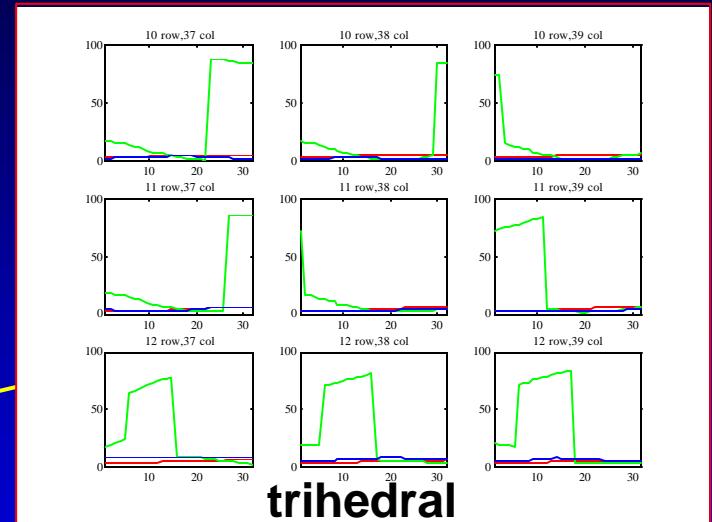
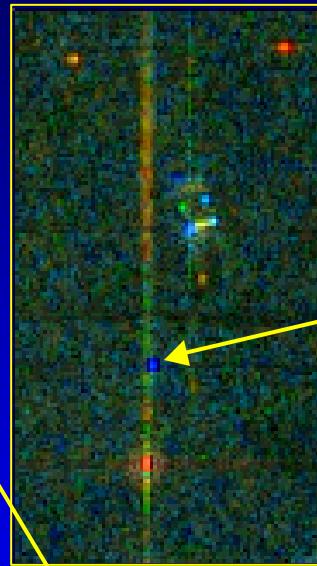
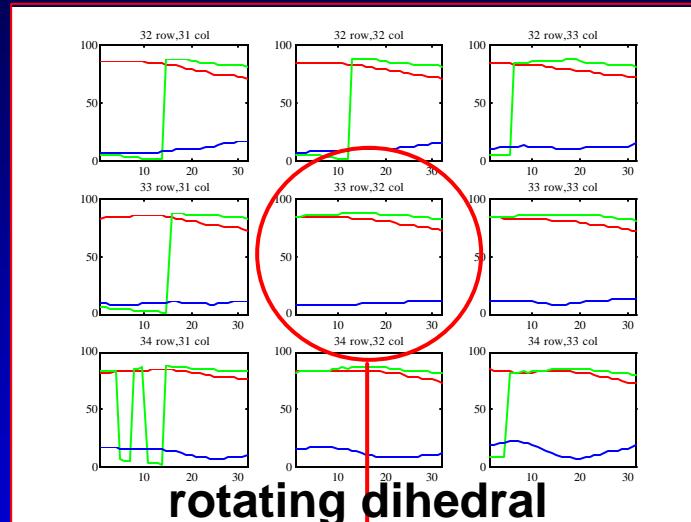
Subaperture Analysis of a, b, H: C060 Dihedrals, Dipole

Plots of a (red), b (green), entropy (blue) vs sensor position along flight path

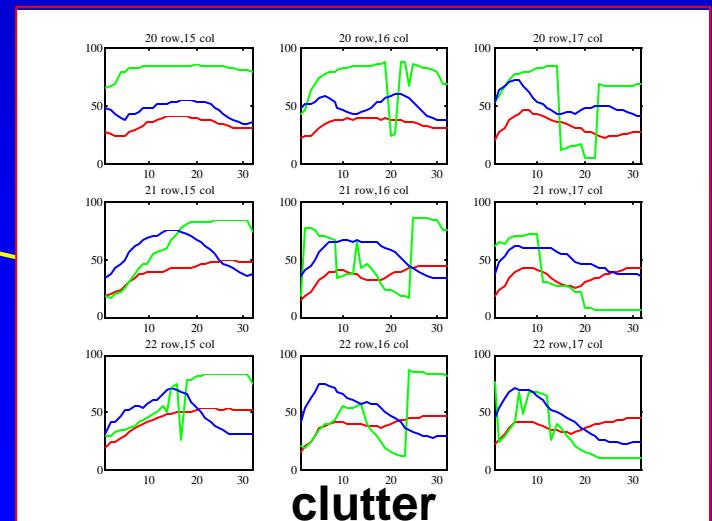
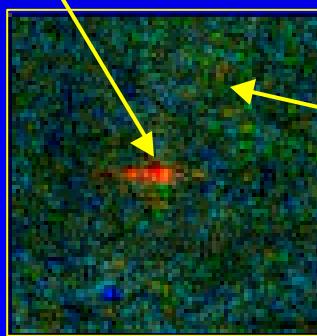
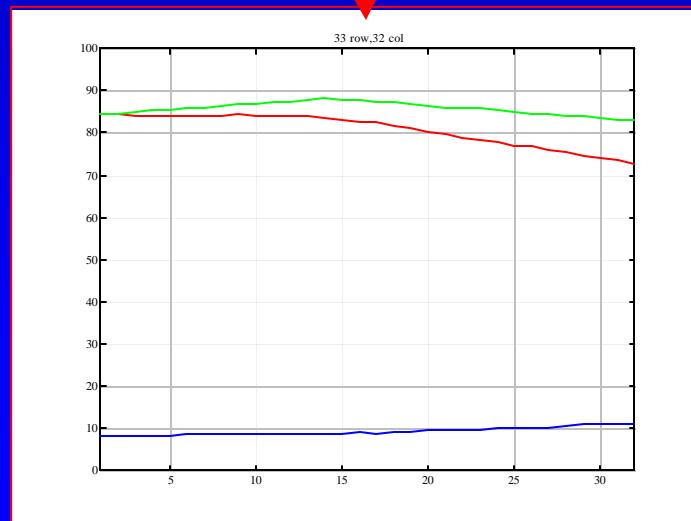


C060 Rotating Dihedral, Trihedral, Clutter

Plots of a (red), b (green), entropy (blue) vs sensor position along flight path

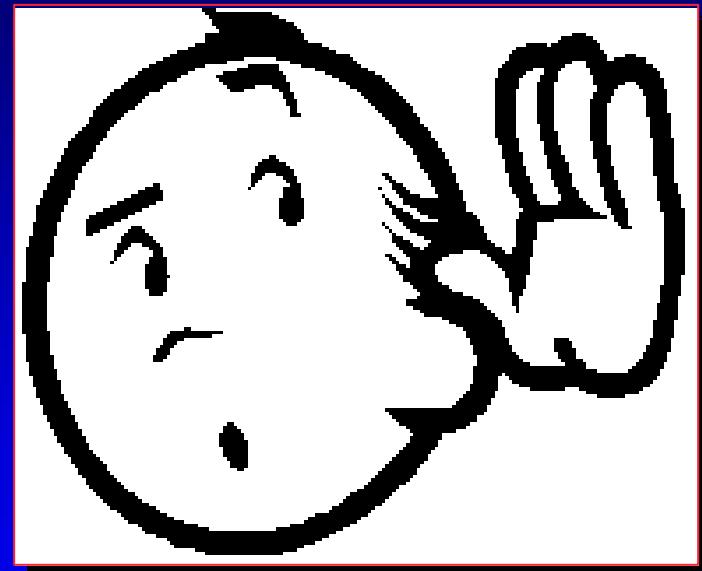


trihedral



clutter

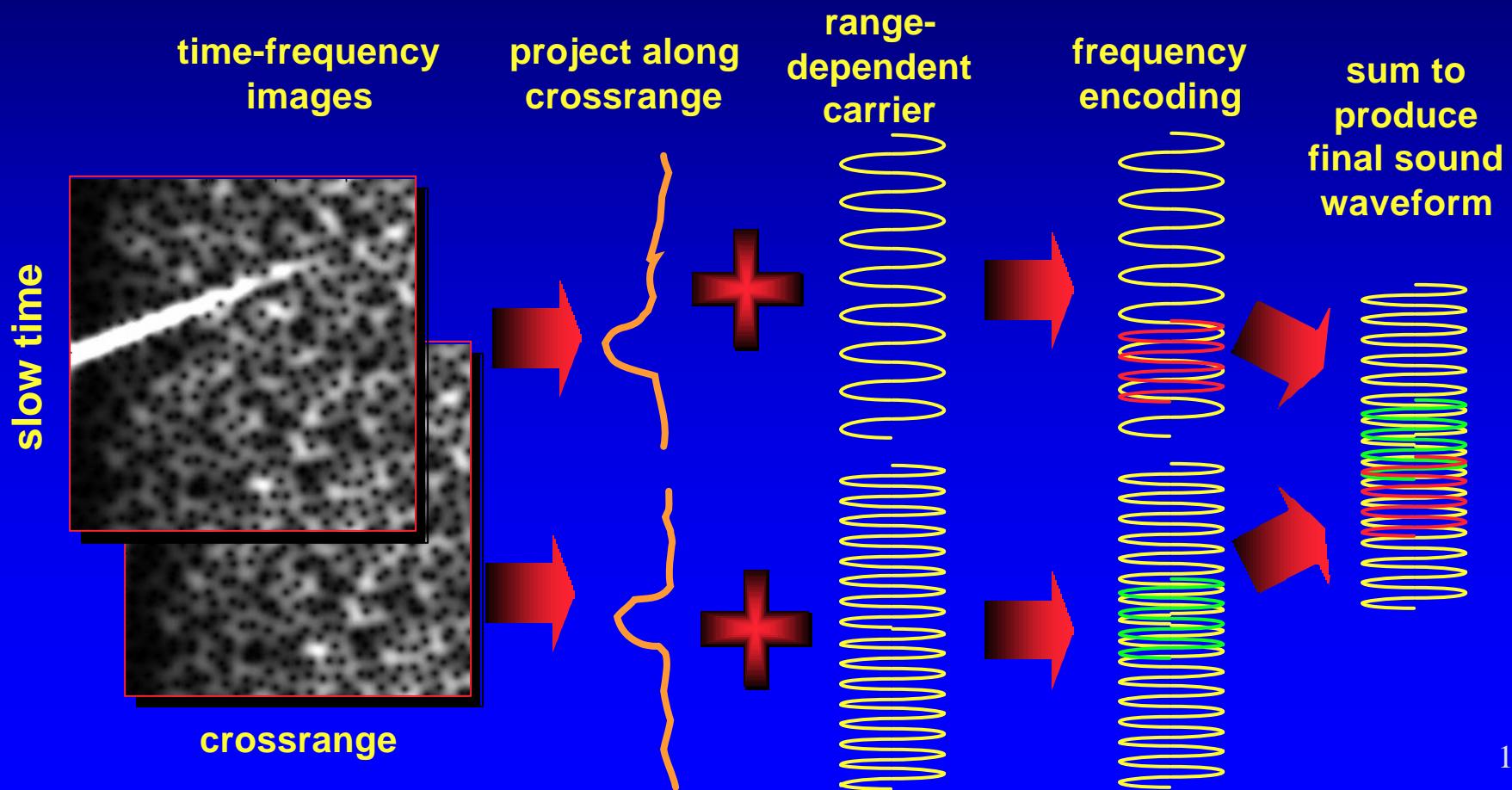
Audio Encoding of SAR Data



Audio Encoding of Slowtime-Crossrange Space

Goal

- Utilize sound as an aid in detecting and characterizing events:
frequency encode events and range line of events



Summary

- Object changes during a SAR acquisition can be detected & characterized
- Pixel stability applications
 - Create visual image of stable / changing regions
 - Define *feature* stability
 - Remove/suppress certain imaging artifacts
- Application to polarimetric data
 - Analyze decomposition products over the aperture
 - Stability, motion, orientation changes
- Audio encoding of changes during acquisition under investigation